NATIONAL RADIO ASTRONOMY OBSERVATORY

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Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Facilitating Opportunities for Flexible,	)	ET Docket No. 03-108
Efficient, and Reliable Spectrum Use	)	
Employing Cognitive Radio Technologies.	)	
	)	
Authorization and Use of Software Defined	)	ET Docket NO. 00-47
Radios	)	(Terminated)

Comments of the
National Radio Astronomy Observatory
Charlottesville, VA 22903

I. Introduction, Background and Summary of Concerns

1. The National Radio Astronomy Observatory (NRAO) is pleased to provide comments in response to the Commission's Notice of Proposed Rule Making and Order FCC 03-322 (hereinafter "The NPRM&O") "Facilitating Opportunities for Flexible, Efficient, and Reliable Spectrum Use Employing Cognitive Radio Technologies (ET Docket No. 03-108)" and "Authorization and Use of Software Defined Radios (ET Docket No. 00-47)."

2. NRAO (http://www.nrao.edu), operated by Associated Universities, Inc., (http://www.aui.edu) under a cooperative agreement with the National Science Foundation, is the largest radio astronomy observatory and one of the largest astronomical observatories of any kind in the world. As such, it is responsible for much of the basic research conducted by the Radio Astronomy Service nationally and internationally. NRAO currently operates the Very Large Array (VLA) in Socorro, New Mexico, the Robert C. Byrd Green Bank Telescope in Green Bank, West Virginia and the Very Long Baseline Array (VLBA), an array of ten antennas spread across the United States from Hawaii to St. Croix. NRAO is also the North American partner for construction of ALMA (Atacama Large Millimeter-wave Array; http://www.alma.nrao.edu) an international facility sited in northern Chile comprising 64+ millimeter/submillimeter wave antennas designed to observe up to 1 THz.

3. As a public institution, charged on behalf of the American people with the conduct, care and encouragement of the practice of radio astronomy, the NRAO is obligated to express its concerns for the continued success of its operations. As participants in one of the so-called passive services, the Observatory and its clients make heavy use of the electromagnetic spectrum, while refraining from marking it in any way. The inherent contrast with active services— which cannot "use" the spectrum except by changing it—creates a dichotomy in the meaning of such terms as "spectrum use" which motivates the Observatory to make this Comment on the Commission's NPRM&O (FCC 03-322).

4. At paragraph 6, the Introduction and Executive Summary of the NPRM&O notes that the FCC will "set out a proposal under which unlicensed devices employing certain cognitive radio capabilities would be permitted to transmit at higher power levels in rural areas and other areas of limited spectrum use." This is a concise summary of those areas of greatest concern to the Observatory, in particular:

   - The meaning of "spectrum use."
   - The definition of some "spectrum use" as "limited."
   - Reliance on placement of radio astronomy stations in rural areas.
   - Proliferation of higher-powered unlicensed devices.
   - Effects of cognitive technologies upon the Observatory's ability to identify sources of harmful interference.

II. Importance of Rural Areas to Operation of Radio Astronomy Stations.

5. Increasing demands on the spectrum, and recent rules restricting certain protections to radio astronomy stations whose locations and service bands have been registered (see http://www.nsf.gov/mps/divisions/ast/about/c_programs_registration.htm), place an increasing premium on operation in remote areas. These remote areas are afforded various special protections, one of which is the existence of the National Radio Quiet Zone about the Observatory's Robert C. Byrd Green Bank Telescope in West Virginia; other coordination zones are documented in footnotes to the U.S. Table of Frequency Allocations. Substantial logistical, financial and other burdens to the Observatory and its clients are specifically associated with operating from such remote areas.

6. The Observatory views the existence of such quiet and coordination zones as an important spectrum management and/or regulatory tool, which acts efficiently to forestall the wider contentions between services, licensed and unlicensed, active and passive, which would inevitably occur if the Observatory were to try to operate in more populous areas.

7. The Observatory notes, however, that there are no specific protections from or requirements on the current use of unlicensed devices, in relation to the existence of these quiet and coordination zones. Therefore it is of great importance to the Observatory that changes in the regulations governing such unlicensed devices should be such as to preserve the Observatory's ability to operate successfully at its stations.

III. Meaning of "Spectrum Use"

8. At Paragraph 36 of the NPRM&O, the FCC notes that "while licensed devices are typically licensed for use in a specific geographic area at a specific maximum power level, unlicensed devices generally have no geographic restrictions on operation and can be used in any location. Because spectrum use in rural areas is generally extremely low, measuring spectrum occupancy is a method that could potentially be used to determine when a device is in a rural area and is eligible to operate at higher power. We propose to permit higher power operation by unlicensed devices in any area that has limited spectrum use, provided the device has capabilities to determine whether it is in an area with limited spectrum use."

9. Use of the phrase "any area that has limited spectrum use" renders the definition of "limited spectrum use" of paramount importance to the Observatory, which conducts its operations exclusively in remote areas chosen so as to have especially low ambient noise. Measurement of spectrum occupancy, or indeed any metric which relies on sampling the electromagnetic spectrum (e.g., the NPRM&O at Para 36, discussed below at 12), cannot gauge possible "use" of the spectrum by the Radio Astronomy Service. In fact, just the opposite is likely; the quieter the environment, the more heavily it could be used for the purposes of the Radio Astronomy Service and the less apparent such "use" might be.

10. Thus it is absolutely essential to incorporate into the definition of the term "spectrum use" some means of including the (licensed) operations of the Radio Astronomy Service, or explicitly to note the limitations of the proposed definition of "spectrum use" with respect to passive uses of the spectrum. This seems not to have been the case up to the present.

IV. Definition of "Limited Use" of a Band of the Spectrum

11. Paragraph 44 of the NPRM&O defines limited use of a band of the spectrum in terms of the band having a certain percentage of spectrum unused, where unused spectrum is defined as spectrum with a measured aggregate noise plus interference power no greater than 30 dB above the calculated noise floor within a measurement bandwidth of 1.25 MHz.

12. This definition is incompatible with both the use of the spectrum by the Radio Astronomy Service (which it fails to recognize) and with the protection of such use, especially given the FCC's intention, expressed at Paragraph 36 of the NPRM&O, "to permit higher power operation by unlicensed devices in any area that has limited spectrum use, ..." The Observatory notes the use of the word "any" in this context, and emphasizes that there seems to be no exception for the health of the radio astronomy station.

V. Means of Controlling Cognitive Radios Within Radio Quiet and Other Coordination Zones

13. Paragraph 57 of the NPRM&O notes the possibility of using "beacons" to disseminate information relating to permitted uses of the spectrum, by whatever means (including but

not necessarily limited to wireless broadcasting). The Observatory notes that the National Radio Quiet Zone and other coordination zones around the stations of the Radio Astronomy Service are large in size but regular in shape, and expresses the wish not to place additional burdens on the spectrum by constructing transmitting beacons in regions where spectrum occupancy is to be kept to a minimum.

14. The Observatory also notes that such a beacon informing devices of the existence of a quiet or coordination zone would always be in its "on" state, as discussed here further at para. 18.

15. Thus, the Observatory favors the use of geographic information, conveyed by existing means such as GPS, to inform cognitive radios that they are in sensitive regions where the proposed definition of "limited spectrum use" could mistakenly encourage their use of higher transmitting power. Such use of location information seems consistent with the frequent discussion of the importance of location throughout the NPRM&O.

VI. Effect of Cognitive Technology on Observatory Operations in Rural Areas

16. Paragraph 20 of the NPRM&O notes that 'a cognitive radio could negotiate cooperatively with other users of the radio spectrum to enable more efficient sharing of the spectrum. A cognitive radio could also identify portions of the spectrum that are unused at a specific time or location and transmit in such unused "white spaces".' Use of cognitive radio capabilities to vary the emission characteristics is mentioned throughout the NPRM&O.

17. Within the National Radio Quiet Zone (NRQZ), the Observatory relies heavily on its ability to track transmissions to their source based on their operating frequency; cognitive technology might thwart such efforts. Also, the Observatory notes that, even though NRQZ coordination for mobile transmitters and unlicensed devices is not required, the Observatory is currently able to track harmful RFI to mobile transmitters or families of devices by their assigned frequency. This is important, as experience has been that, if an interference source can be found, then, through mutual cooperation, it is usually possible to manage such interference without recourse to use of formal legal processes. The use of frequency flexible technology in the NRQZ could make it much more difficult to accomplish this.

18. The Observatory believes that the device-level negotiation discussed in the NPRM&O at 20 (para. 15 above) is supplanted by the prior negotiation culminating in the existence of the present quiet and coordination zones. The National Radio Quiet Zone is by no means an exclusion zone, as, typically, hundreds of requests for transmitters are examined and approved in fairly routine fashion each year by the Observatory. However, within this framework, the possibility to negotiate spectrum sharing on a moment-by-moment basis with individual devices simply does not exist.

VII. Summary of These Major Concerns

19. The definition of spectrum use or limited spectrum use solely in terms of the presence of signal above an idealized noise floor, to say nothing of signal levels 30 dB higher, may be

well-suited to spectrum use by active services. Yet it is entirely antithetical to use of the spectrum by the Radio Astronomy Service. The essential distinction is that the signals of interest to radio astronomy are actually components of the generalized cosmic noise, even in the absence of other noise components (receiver noise, environmental radiation, etc.), and the frequency of emission and received power levels of cosmic sources are generally not susceptible to human influence.

20. For this reason, we most strongly urge the Commission to review its intention, as stated at Paragraph 36 of the NPRM&O (quoted at III. above), to allow higher-powered operation of unlicensed devices in any area meeting the Commission's definition of limited spectrum use, when the definition of limited spectrum use has been so closely tailored to the active services. Specifically, we ask that the Commission either

- adopt a more general definition of spectrum use which explicitly recognizes passive use of the spectrum, or
- take note of specific exceptions to the proposed definition which acknowledge the existence of certain radio quiet or coordination zones and, more generally, the activities of the Radio Astronomy Service,

and thus continue to protect the Radio Astronomy Service in its remote locations. As discussed at paras. 13-15 above, we advocate the use of GPS and other existing location services to inform spectrum users of the need to respect the variously codified, allowed levels of harmful interference to the Radio Astronomy Service within certain well-defined zones.

IX. Radiometers and Detection of Signals Below the Noise Floor

21. Paragraph 25 of the NPRM&O describes the use of various receiving and computational techniques to detect signals below the ambient noise floor. It takes note of "radiometric detectors which only function if the signal is greater than the noise floor in the receiving system." It also notes the possibility of slower than real-time monitoring by other technologies to lower the signal level which is sensed in the presence of noise.

22. As the Observatory set out earlier to the FCC in its Comments on the Interference Temperature NOI (FCC 03-289), in particular see paragraph A15, radio astronomy profitably sums data from radiometric detectors for (in some cases) hundreds of hours, in order to detect signals many orders of magnitude below the noise floor. But even much shorter periods of observation will suffice for reliable detection of signals well below the noise floor, when taken over sufficient spectral bandwidths.

23. In particular, the level of detectability is enhanced proportional to the square root of the product of the bandwidth and period of observation, providing that the conditions of observing are steady in time and uniform over the observing bandwidth (both of which conditions are typically violated, of course, by harmful interference). Thus, over a 1.25 MHz bandwidth (the reference bandwidth for the proposed definition of limited spectrum use in the NPRM&O at para. 44), a room temperature (300K) radiometer will,

in 1 second, produce an rms temperature measurement fluctuation below 0.5 K, or more than 27 dB below room temperature.

VIII. Proposed Levels for Out of Band Emissions

24. At paragraph 42, the NPRM&O notes that current limits on out of band emissions falling in some unrestricted bands are expressed as proportions of the in-band power levels. Thus, some allowed extra-band power levels would rise if current rules are applied to higher-power unlicensed devices. Allowing increased out of band emissions in any part of the spectrum will act in opposition to the stated intent of the FCC, in this and many other instances, to increase the availability of spectrum. With the present emphasis on developing higher levels of cognition and control in transmitting devices, the effort needed to achieve somewhat more stringent limits on their undesired output products might prove a worthwhile source of added usable spectrum.

Respectfully submitted,

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April 26, 2004

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